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MULTIENVIRONMENT ACTIVE RF SEEKER TEST AND EVALUATION PROGRAM (--ETC(U)
SEP 79 DAAK40-78-C-0046
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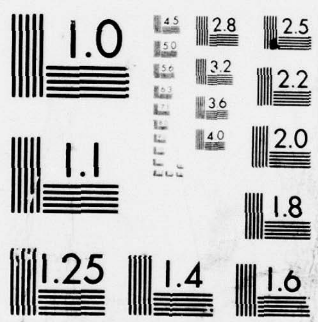

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FOREWORD

The Multi-Environment Active RF Seeker Test Program (MARFS Test) was performed by Martin Marietta Corporation, Orlando, Florida under contract DAAK40-78-C-0046. This report covers work performed from 9 January 1978 to 30 September 1979. It is submitted in fulfillment of data item A001, Final Report. The U.S. Army Program/Project Manager was:

Mr. Lloyd Root, Jr. DRSMI-RER
RF Guidance Technology
Advanced Sensors Directorate
Technology Laboratory
U.S. Army Missile Command
Redstone Arsenal, Alabama.

This program was the third phase of MARFS development. Phase I was a study program. The breadboard seeker was built in Phase II.

CONTENTS

1.0 INTRODUCTION AND TASK DESCRIPTION

1.1 Introduction

On 9 January 1978 the MARFS seeker was delivered to MIRADCOM. The MARFS seeker is a 17 GHz circularly-polarized 10-watt pulsed solid-state seeker employing polarization agility, monopulse tracking, and polarization diverse signal processing. ~~This~~ seeker was developed under contract DAAK40-75-C-0891 for MIRADCOM. It was determined, at that time, that extensive tower and captive flight tests would be required to establish the usefulness of this particular seeker design and to collect data enabling further developments of detection and tracking algorithms. To facilitate these tests, Martin Marietta was awarded Contract DAAK40-78-C-0046 to provide maintenance and calibration, and to operate the MARFS seeker during these tests.

The ~~final~~ report describes the support provided during these tests. It lists the tests supported, the alterations made, the maintenance performed, and the additional problems that were encountered.

1.2 Task Description

The MARFS task was comprised of two phases or subtasks that were performed by Martin Marietta Aerospace, Orlando Division. Phase I, called the Maintenance and Installation Phase, required Martin Marietta to install and repair MARFS as required to meet the overall test schedule. MARFS was initially installed in the F-1 Tower at Redstone Arsenal. It was subsequently moved to the MICOM E-O Laboratory, reinstalled on F-1 Tower, moved to Alpha Radar Tower, installed in the AMS helicopter, moved to the Martin Marietta Radar Tower in Orlando, and reinstalled in the AMS aircraft. Phase I effort also included the maintenance, repair, and calibration of the MARFS equipment throughout the performance period of the contract.

Phase II, Test Phase, required Martin Marietta to perform all activities required by the test plan as to the operation of the MARFS equipment, operation of the data recording equipment, and delivery of the data tapes to the government.

Five major test sequences were called for in the test plan.

Sequence I was Fall-Winter Static Tests. The objectives of these tests were to check out MARFS and the instrumentation system under field operating conditions; collect data to characterize various target/clutter cell combinations; and to characterize the detection, acquisition, and tracking performance of MARFS.

Sequence II was the installation of the MARFS equipment in the AMS helicopter. This sequence also included checking out the instrumentation and recording system and the radar/instrumentation interface.

Sequence III was the Winter Captive Tests. The objectives of this sequence were the same as the objectives of Sequence I, subject to the limitations of airborne testing.

Sequence IV was the Spring-Summer Static Tests. This sequence was intended to be a repeat of Sequence I under Spring and Summer climatic conditions.

Sequence V was Summer Captive Tests. This sequence was essentially a repeat of Sequence III with two exceptions. It was performed under different climatic conditions, and considerably more effort was spent on collecting aimpoint wander data to facilitate terminal guidance accuracy estimation.

2.0 OVERALL SCHEDULE

The schedule of work performed under contract DAAK40-78-C-0046 is shown in Figure 1.

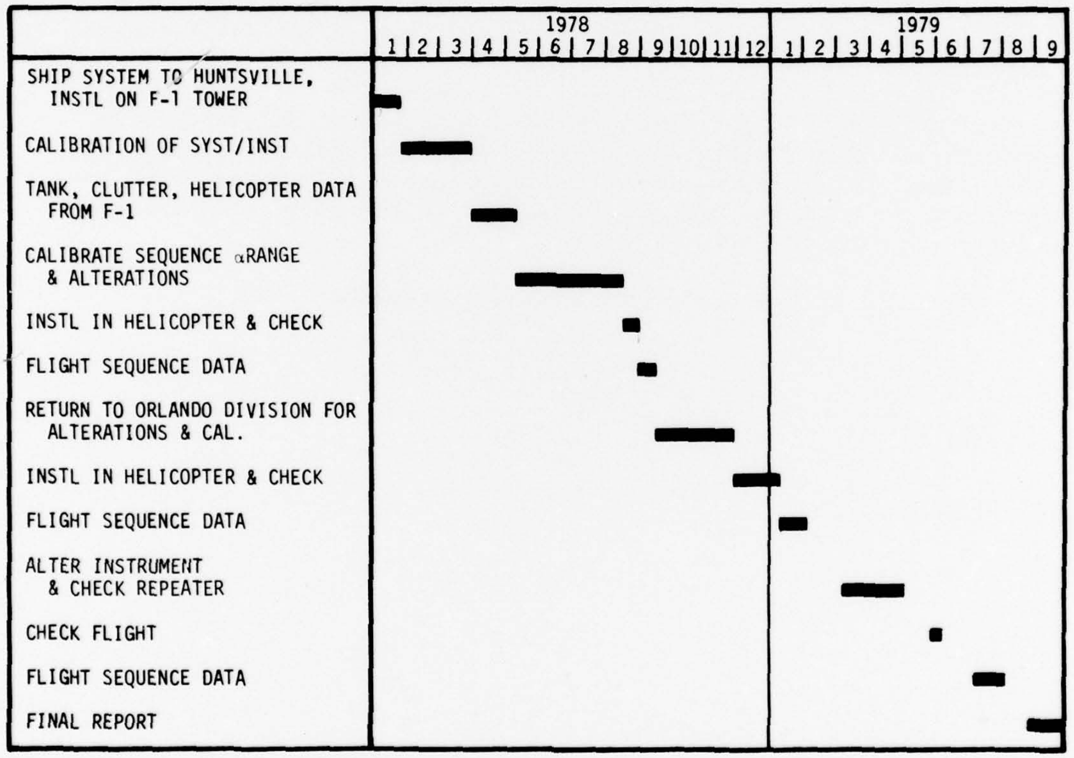

Figure 1. Program Schedule

In January 1978, MARFS was delivered to Redstone Arsenal, Alabama, and installed on the F-1 test tower. During February and March 1978, the necessary instrumentation interface electronics were designed, built, and tested, and the complete radar/instrumentation system was calibrated.

During April and early May 1978, the Sequence I - Fall-Winter Static Tests - data was taken. During June and July MARFS was moved to the Alpha Radar Test Tower. Here, necessary alterations were made and the system was recalibrated. Additional static testing was performed from the Alpha Tower during the first half of August.

In late August MARFS was removed from Alpha Tower and installed in the AMS helicopter. Sequence II data (system checkout) was taken at this time. In late August the Sequence V data (Summer Captive Tests) were taken.

After the Summer Captive Tests, MARFS was returned to Martin Marietta for extensive alteration, refurbishment, and checkout. MARFS was returned to Redstone Arsenal and reinstalled in the AMS helicopter in December 1978. Sequence III data, Winter Captive Tests, was taken in January and February 1979.

Several alterations to the instrumentation interface equipment and to the active calibration target were made during March, April, and May 1979. A test flight for these alterations was made during the first week of June 1979.

An additional flight test sequence was flown in July and early August 1979. This flight test sequence provided additional aimpoint wander data. In addition, more system performance data was taken to characterize system performance subsequent to the modifications made during the spring and summer.

This final report was prepared during September 1979.

3.0 MAINTENANCE

Problems requiring maintenance action may be grouped into four broad categories: RF component failures, low frequency component failures, subsystem problems, and human error. Table I lists the major MARFS maintenance items performed by category with cross-reference to the Test Log test number.

TABLE I

Seeker Maintenance

Maintenance Items	Test Log Test No.
1 RF component failure	
Bad cables	13, 54, 63
Bad connectors	06, 019, 020
Impatt failure	40, 46, 63
2 Low frequency component failure	
Solder joints	37, 77
Wrong valve	77
Bad dip	74
3 Subsystem problems	
Exciter stability	04, 018, 34, 35, 61
Circuit charges required	04, 43, 49, 74, 77, 79
4 Human error	
Put in circulator backwards	40

The RF cable-related failures all occurred in the RF cables used to connect the antenna to the mixers. The cables are a new design utilizing a dielectric of Teflon foam that provides low loss at K_u-band. These are high compliance cables with a minimum band radius of 1/2 inch. These characteristics permit replacing conventional rotary joints with cables. Subsequent to delivery of the MARFS cables, the vendor has developed new techniques for fabricating the cable assemblies, which should correct cable-related problems.

Of the three connector-related failures, two were on the cables discussed in the preceeding paragraph. The other failure resulted from improper connector installation.

The low frequency component failures were routine and to be expected in an equipment as complex as MARFS.

Two problem areas resulted from subsystem problems. Instabilities in the exciter caused several problems. These should be corrected by reworking the exciter, paying particular attention to phase-locked loop stability margins and proper temperature compensation and/or control. The other design related problem was that several modifications were needed to make the MARFS equipment and instrumentation subsystems (analog tape, multiplexer and videotape recorders) compatible. Appropriate design changes have been made in all the instances noted, and no further problems are expected in this area.

There was only one failure directly attributable to human error. A circulator was improperly installed, causing damage to one receiver channel. Problems of this nature are avoided by properly training and supervising maintenance personnel. Over a year of maintenance and testing have occurred since the last human error induced problem, indicating that appropriate measures have been taken.

4.0 ALTERATIONS

Some rather extensive alterations were made to the MARFS system hardware during the test contract period from January 1978 through August of 1979. These required modifications fell into two major categories:

1 Modifications and/or additions necessary to properly interface the contractor hardware with the GFE flight test aircraft and the airborne data instrumentation equipment.

2 Modifications and/or additions found to be required during testing that would enhance the data-gathering capability of both the delivered hardware and the flight test equipment. This included changes to existing hardware and test plans as well as implementing additional hardware to obtain in-flight calibration references for target and clutter data.

The modifications made are listed in chronological order of occurrence in Table II and identified as to which of the above two major categories they fall under. Each alteration is discussed briefly below.

Discussion

1 Designed and fabricated circuits and cabling required to instrument seeker signals identified as σ_A, σ_T, β_A, β_T, $k(\log \sigma_A - \log \sigma_T)$ and $\sin \beta_T - \text{Sin } \beta_A$.

2 Designed and fabricated interface cabling, buffer amplifiers, and scaling circuits to utilize the GFE 13 channel FM/FM multiplexer to interface low frequency seeker signals with the instrumentation recorder.

3 Modified the MARFS TV video signal distribution and video recording system to interface properly with the GFE IRIG time-code generation hardware.

4 Modified MARFS instrumented AGC signals to record composite AGC, clutter AGC, and signal AGC independently.

5 Fabricated a calibration source unit and modified instrumentation cabling to provide calibration signals on the M14-G recorder FM channels.

TABLE II

Alterations

Alteration		Category
1	Provide sampled video signals for recording	1
2	Low frequency signals interface with FM/FM multiplexer	1
3	Modify FOV video system to add IRIG time	1
4	Make composite, signal, and clutter AGC voltages available for recording	2
5	Add calibration signals for insturmentation tape recorder FM channels	2
6	Increase servo loop gain	2
7	Make AGC operate on signal amplitude in all modes	2
8	Channel six blanking	2
9	Make sampled horizontal and vertical video available for recording	1
10	Add capability to angle track on amplitude data when processing phase data	2
11	Make FOV TV sync signals and power supply voltages available for alphanumeric unit	1
12	Added new calibrator with audio amplifier	1
13	Added monitor signal panel	1
14	Add solid state amplifiers to active calibrator	2
15	Change FOV video system to color	1
16	Enable auxiliary gate sampling either before or after target gate	2

6 Modified the MARFS gimbal servo loop to provide higher gain in the rate loop to decrease aimpoint wander.

7 Modified AGC circuitry to operate on nonlimited amplitude data when processor is operating on limited data. This modification was made to provide proper receiver gain control based on signal amplitude when the signal processor input is phase data (phase detector outputs when inputs are limited). The amplitude reference is necessary since the phase data has no signal strength information when the inputs to the phase detectors are limited.

8 Modified receiver output circuits to blank output on all frequency number six pulses. This modification was required because one of the two exciter reference oscillators beats with the local oscillator when it is tuned to frequency number six to give a different frequency that falls within the bandpass of the receiver. Isolation between the exciter and the receiver front end is not sufficient to reject this signal. This resulting signal is of sufficient amplitude to cause a baseline shift in the detector outputs, and if left uncorrected, prevents proper thresholding of subsequent video signals. The modification is implemented by using the AGC line to turn all gain controlled stages in the receiver to the minimum gain condition when the receiver is turned to frequency number six.

9 The horizontal and vertical receiver sum channel square law detector outputs were brought out to the instrumentation interface unit for sampling and recording. Previously, only the combined horizontal plus vertical output was recorded.

10 During initial phases of the test program, it was found that under some conditions angle track performance was unsatisfactory when the signal processor, and therefore the angle track circuits, were operating on phase (bipolar video) data. This alteration allowed the angle track circuits to operate on amplitude data (square law detector output) when the signal processor operates on phase data (quadrature phase detector output).

11 A microprocessor controlled alphanumeric unit was added to the instrumentation system to allow display and recording of several system parameters in alphanumeric format on the FOV video. This modification provided the TV sync signals and power supply voltages for the alphanumeric unit.

12 A new calibrator was added to enable recording calibration signals on the instrumentation tape recorder. The new unit included an integral audio amplifier needed to improve the quality of the voice recording channels and a fail-safe design to prevent inadvertant loss of data due to the "calibrate-data" switch being left in the wrong position.

13 To ensure proper operation of MARFS and the instrumentation system during captive flight tests, it was necessary to monitor several signals on an oscilloscope. This modification made the necessary signals available to the operator on a convenient rotary selector switch, the output of which feeds an oscilloscope.

14 The active calibrator, as originally built, used TWT amplifiers, which required a portable gasoline powered generator to provide power for the system in the field. This modification replaced the TWTs with solid state amplifiers and replaced the gasoline generator with a rechargeable storage battery. Thus the active calibrator was much easier to use under field conditions.

15 The field of view (FOV) video system installed in the AMS gimbal caused several problems during the test program. Basically, the equipment was obsolete and uneconomical to repair and keep operational. The black and white TV camera and electronics unit were replaced with a color camera, new electronics unit, and a remote-controlled zoom lens system. This modification greatly enhanced the data gathering capability of the MARFS/AMS system.

16 To properly characterize some clutter cells, particularly tree lines, it was necessary to sample and record video from a reference target at ranges shorter than the target (clutter cell) range. This modification permitted placement of the auxillary gate, used to sample the reference target video pulse either before or after the target gate.

5.0 INSTRUMENTATION INTERFACE

The instrumentation concept for the MARFS Test Program was to record system performance type data on a Government-furnished instrumentation tape recorder and to make video recordings of the AMS FOV TV and of an oscilloscope which displayed range-gated, square-law-detected and phase-detected video pulses. Early tests revealed the need to provide better amplitude and phase data than was available in the oscilloscope video recordings. Therefore, appropriate modifications to the MARFS hardware and to the instrumentation system were made to enable recording, on a pulse-by-pulse basis, the amplitude and phase of the range-gated target.

Numerous other changes to the original instrumentation scheme were made as experience was gained during the Test Program. Tables III, IV, and V are intended to document the final configuration of the MARFS/AMS instrumentation.

Table III lists the recording equipment and its use.

TABLE III

Recording Equipment

Equipment	Recorded
Videotape recorder (VTR) Number 1	AMS FOV video with superimposed radar symbology, alphanumerics, IRIG time, and voice
VTR Number 2	Range gated amplitude and phase video with superimposed IRIG time and voice
Instrumentation recorder	See Table IV

Table IV contains the channel assignments and signal descriptions for the 14-channel instrumentation tape recorders.

Table V lists the subcarrier assignments and signal descriptions for the 13-channel FM/FM multiplexer.

TABLE IV

Instrumentation Recorder Channelization

Channel No.	Mode	Signal Description	Voltage Range (V)	Info B/W (kHz)
1	Direct	FM/FM multiplexer	See Table V	
2	Direct	Control data tachometer		
3	FM	Composite AGC	0.5 to -4.4	
4	FM	Target gate horizontal cross section	0 to -4	10
5	FM	Target gate vertical cross section	0 to -4	10
6	FM	Auxiliary gate horizontal cross section	0 to -4	10
7	FM	Signal AGC	+0.5 to -4.4	100
8	FM	Frequency + peak is lowest freq 25 ea 20 MHz FM 16.75 GHz	±1	10
9	FM	Auxiliary gate vertical cross section	0 to -4	10
10	FM	Target gate H + V cross section	0 to -4	10
11	FM	Auxiliary gate H + V cross section	0 to -4	10
12	FM	Target gate polarization angle	-4 to +4	10
13	FM	Auxiliary gate polarization angle	-4 to +4	10
14	FM	IRIG-B time	-2 to +2	1

TABLE V

Multiplexer Subcarrier Assignments

Channel No.	Parameter	Information Bandwidth (Hz)	Parameter Variation	Voltage Level (V)	Subcarrier (kHz)
1	Gimbal pitch	300	±1.25 deg/V	±2.5	3.9 (3.607/4.193)
2	Pitch error	20	+4 to -4 deg	+2.5 to -2.5	5.4 (4.995/5.805)
3	Yaw error	20	+4 to -4 deg	+2.5 to -2.5	7.35 (6.799/7.901)
4	Radar altitude	10	0 to 5 kft	-2.6 to +2.6	10.5 (9.712/11.288)
5	Clutter AGC	10	+0.5 to -4.4V	-2.5 to +2.5	14.5 (13.412/15.588)
6	Gimbal yaw	300	±1.25 deg/V	-2.5 to +2.5	22 (20.35/23.65)
7	Manual AGC	Analog dc	+0.5 to -4.4V	0 to 5	30 (27.75/32.25)
8	Relative cross section	10		+2.5 to -2.5	40 (37/43)
9	Relative phase	10		+2.5 to -2.5	52.5 (48.562/56.438)
10	Range	10	0 to 5 km	0 to 5	70 (64.75/75.25)
11	Range track	10	Yes/no	4/0	93 (86.025/99.975)
12	Target detect	10	Yes/no	4/0	124 (114.7/133.3)
13	Voice	100	0 to +2.0V	±2.5	165 (152.624/177.375)

6.0 SUMMARY AND RECOMMENDATIONS

Results of the MARFS Test Program validate the fundamental design philosophy for the equipment. Two concepts drove the MARFS design. First, polarimetric processing was to be employed. Secondly, a wide range of operating modes was incorporated to make the radar as versatile as possible.

The versatility built into MARFS, the ability to generate and process amplitude data, phase data, or phase and amplitude data is enabling MICOM to collect an extremely wide data base. This data base will be invaluable in designing the next generation MMW seeker.

In summary, the MARFS Test Program demonstrated the capability of the MARFS radar to generate extremely valuable data that describes the performance of airborne radar seekers operating in several different modes and to quantify the amplitude and phase signature of many targets and types of background clutter.

As with any program involving radically new equipment, some problems occurred during the MARFS Test Program. Recommendations to correct the major problems encountered are listed below.

1. Some types of clutter were not measured at long ranges because the system became noise limited. The transmitter power delivered to the antenna should be increased by at least 13 dB. A technical discussion of one approach to implementing this recommendation is contained in Appendix B.

2. Most of the MARFS hardware-related problems encountered were with the exciter. The exciter should be redesigned, paying particular attention to improving stability and eliminating the frequency six interference.

3. The signal processor should be redesigned to optimize the processing of the phase signature of armored targets. The new signal processor should be programmable to enable testing several detection algorithms so that an optimum processing scheme can be developed. Appendix C contains a description of a microprocessor-based implementation of this recommendation.

4. The instrumentation system should be converted to an all-PCM system compatible with the MICOM PCM ground station. A discussion of this recommendation is contained in Appendix D.

5 The existing instrumentation interface unit, the calibrator, the alphanumeric unit, and the monitor switch panel should be repackaged into one rack-mounted unit.

6 The equipment layout in the AMS helicopter should be redesigned to provide better access to operating controls and better visibility of displays.

7 The parts of the AMS system mounted externally on the helicopter should be made weatherproof to allow adverse weather testing.

8 The AMS gimbal controls should be rewired so that the gimbal can be fixed in pitch while continuing to be steered in azimuth. This change would enhance the MARFS/AMS capability to take quantitative target signature data.

APPENDIX A

TEST LOG

APPENDIX A

TEST LOG

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
001	1/22	Calibrate interface unit.	D. Bowyer	F-1 Tower	Analog data tape M-1	Verify scaled outputs to handle 20 dB SN ratios.	Negative		FM/FM is not calibrated.	
002	1/24	Calibrate interface unit.	D. Bowyer	F-1 Tower	Analog tape M-2	Verify scaled outputs to handle 20 dB SN ratios.	Negative		FM/FM is not calibrated.	
003	1/27	System	D. Bowyer	F-1 Tower	M-3 analog tape	Exercised all MARFS controls for recording various MARFS signal outputs to instrumentation.	Goals accomplished	None	None	
004	1/27	Acquisition, tracking range, & angle.	D. Bowyer	F-1 Tower		Acquire at 2000 m^2 target 1 deg at 3.4 km (Figure 1).	Negative		Crosshairs tear up scene with contrast.	Redesigned sync separator.
								Exciter agile loop not locking.		Had to adjust bias control.
								No signal AGC; had to use MGC.		Ckt loaded down, made ckt change.
								No angle track.		Had to adjust the offset voltage in servo loop, causing angle error drift $\Sigma - J\Delta$.
										Adjusted sample and hold pots.
005	2/6	Transmitter power test	D. Bowyer	F-1 Tower		Measure transmitter power as function of frequency (1-25).	Unbalance occurs due to 6 dB drop in power at frequencies 11 & 21.			
006	2/8	Exciter output power	D. Bowyer	F-1 Tower		Measure using exciter power at various points vs freq (1-25).	18-19 dB max power.	ΣV channel not operating satisfactorily.		Found gold & silver on Sigma V switching circulator output connector.
							3 dB shift over freq range.			After fixing problem data showed 1 dB variation over freq range PA on and off.
						Measure same as above with PA on & off.	4 dB variation vs freq.			

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
007	2/13	Acquisition & Tracking	D. Bowyer	F-1 Tower		Acquire and track (range & angle) 2000 m^2 target at 3.4 km, 0 deg elev at Bradford Mountain.	Acquired and tracked.	Exciter agile loop broke lock.	Could not see target in video; need scope for A scope video.	Adjusted exciter agile slew bias.
008	2/15	Acquisition & Tracking	C. Iden	F-1 Tower with helicopter		Acquire helicopter flying away at 9 deg ascent angle. Mounted 600 m^2 corner reflector on helicopter flying away.	Negative (could not acquire target) OK			After helicopter reached 2.2 km range, AGC signal reversed its slope and started putting more attenuation in receiver for duration of run. System can angle track to 3.4 km and range track to 4.5 km
009	2/17	Calibrate AGC & interface unit	C. Iden	F-1 Tower		Set up various corner reflectors (2000 m^2-22 m^2) at 300m & 500m ranges, short pulse mode.	AGC looked good for stationary targets and stationary clutter. Tracked in all modes (NPD & PPD) with PPD(H) mode not tracking a 22 m^2 target (300 or 500)m.			
010	2/20	System calibration (tape)	C. Iden	F-1 Tower		Exercised MARFS controls for recording various (MARFS) signal outputs to instrumentation.	Negative		FM/FM multiplexer out of calibration.	

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
011	2/21	Investigate AGC problem	C. Iden	F-1 Tower		Pointed seeker into sky & ran range gate out with transmitter both on & off, observing AGC voltage. Varied K_1(0-7) STC (1-12).	Signal AGC normal. Clutter AGC normal. STC counteracts with signal AGC when STC is on.			
012	2/23	Investigate AGC problem	C. Iden	F-1 Tower with helicopter assisting		Helicopter ascended 9 deg STC=12 k_1=7.	During runs 1 & 2 composite AGC OK. During run 3 composite AGC reverses slope at 2.2 km in range.		No A Scope recorded.	Need to set up recorder calibration for voltage input. Range 0.5V to -4.4V into the recorder.
						Helicopter flew away straight and level (500m) STC=11 k_1=7.			Clutter AGC and signal AGC saturate recorder.	
013	2/28	Phase & amplitude alignment	C. Iden	F-1 Tower		Move 3 deg off boresight up and to the right; observe and record AEY & AEP in all MODES (NPD & PPD).	Signal was down in IF processor outputs for NPD (sum) (yaw) channels, NPD (V) yaw, & PPD (V&H) compared to acceptance data.			Channels low compared with acceptance data. If processor sent to Orlando. Showed OK during tests performed there.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
										Conclude an intermittent occurred. Cable disassembled and assembled cleared problem.
014	3/3	Xmtr power test	C. Iden	Micron F-1 Tower		Measure PA output at ΣH, ΣV J(4), & (5). Inputs to receiver over freq (1-25).	Sum channel vertical and horizontal inputs to receiver vs freq were normal (2 dB variation over freq).			
015		Exciter output	C. Iden			Measure exciter output vs freq.	2 dB variation across freq band.			
016		Circularities test				Circularity test of transmitter.	1 dB separation for RHC. In LHC mode freq 12 showed 4 dB variation with 2 dB variation at other freq tested.			
017	3/8	Circularities	C. Iden			Same as 014. Measure isolation RHC to LHC.	2 dB variation across freq band (1-25) 16 dB isolation recorded.			
018	3/9	Acquisition & Tracking	C. Iden	E-O Lab		Track 50 m^2 corner reflector at 130m range. Track biconical 70 m^2 at 130m range.	Will not detect in PPD both freq agile on.	After 1.5 hr exciter agile loop broke lock.		Polarity is + ch 5; - ch 15 & + ch 25.
019	3/10	Transmitter power test	C. Iden	E-O Lab		Determine transmitter power.	Power in sum (V) channel low at J(5) input to receiver.	Bad connection J(5) sum (V) Channel.		

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
020	3/10	Exciter power test	D. Bowyer	E-O Lab		Using exciter check signal level at sum channels input of receiver before and after circulators.	RHC & LHC show 12 dB variation in power vs freq. Sum (V) channel J(5) shows 15 dB isolation (RHC-LHC) after isolators and 26 dB isolation (RHC-LHC) before isolators connected.	J5 circulator has bad connector.		Replaced J-5 isolator.
021	3/14	Phase & amplitude alignment	D. Bowyer	E-O Lab		Same as 013. Acquire & track 200 m^2 target at 140m (Figure 12).	LHC - all negative responses but some freq weak. Good all modes except NPD (V). After adjustment all channels peaked with right sense.			Readjusted sum channels phase. Found angle error curve in NPD-V weak and reversed sense. Readjusted phase in all channels.
022	3/15	Calibrate interface unit	D. Bowyer	E-O Lab		Calibrate σ_T, σ_A, β_T, β_A.	Negative. DC offset and lack of gain.		Interface unit.	Added offset, buffered video outputs, and adjusted gain in feedback loop.
023	3/18	Calibrate interface unit;	D. Bowyer C. Iden	Micro E-O Lab		Track 50 m^2 target at 72m ref level = 0 dB & 0.05V. Track 600 m^2 target at ref level =4.74 dB.	Sample: σ_T = 0.52V σ_A = 0.45V $\Delta\sigma$ = 0.07V $\Delta\sigma$ in NPD looks good $\approx$ 0.020 $\Delta\beta$ in PPD both look good $\approx$ 0.3V	Readjust interface unit σ_A = 0.524 σ_T = 0.540 $\Delta\sigma$ = 0.03V		No clutter AGC.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
						Track 200 m^2 target at ref level =9.2 dB. Track 100 m^2 target at ref level =-18.77 dB.				
024	3/22	Calibrate interface unit;	D. Bowyer C. Iden			Looking for single mode to give σ & β data tried NPD sum, PPD both, & NPD none.	No solid lock PPD none.		Analog tape not degaussed. IRIG timing offset preventing proper video recording.	
025	3/29	Clutter AGC investigation	D. Bowyer	F-1 Tower	M-	Trace wiring, check voltages per schematic. Test after change.	Clutter AGC varied from +8 to +10V. Clutter AGC varied +2.37 for K2=7 to +2.90 for K1=0. Clutter AGC OK.	Clutter AGC Signal AGC	Channel 9 pathed wrong for strip out.	Changed feedback resistors in circuitry and recorded K1-7 vs clutter AGC.
026	3/30	Acquisition & tracking	D. Bowyer	F-1 Tower	M-	Acquire and track 600 m^2 and 2000 m^2 targets at 1.7 km. Manual & auto AGC. Obtain fastest rate by which to recover valid data. Range rate compensation (20-120) knots was used to scan target.				Recorded K1-7 vs signal AGC. After patch was changed signals were recorded OK.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
027	4/4	Identify & locate targets of interest.	D. Bowyer	F-1 Tower	M-	Bradford Mountain. 200 m^2 base tower 0.33 km. Large tower at 1.611 km. 2000 m^2 near Martin Rd. R=1692 km. 600 m^2 in front of above, R=1.662 km. Drop test facility R=2.94 km. Tree line midpoint Wheeler reservoir R=2.109 km.	Acquired and tracked targets as described well within (+/-) 1 deg in all NPD Modes.	PA overheating.		Put up sun shade and added cold water.
028	4/5	Clutter map K	D. Bowyer	F-1 Tower	M-10,11, 12, MV7	Track 2000 m^2 on Bradford Mountain at 3.433 km. Lock on to 2000 m^2 target and Hill 603 to benign cell No. 2 at 3.4 km freq agile; POL agile on & off. Disengage clutter AGC, closed loop, pitch up 20 deg, range track off. Pitch down and put up successive targets on Hill 603 (2000 m^2 thru 22 m^2).	AGC clutter map radial showed jump of 2.1 signal AGC.		MV-9 did not record video.	Disabled AGC bias so STC-12 disables bias as well as wave foam.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
						In freq agile, make clutter map lock up Bradford Mountain, using RG comp=20 knots move down mountain =0.5 km and up mountain +0.5 km. Return to benign cell No. 2 and calibrate. Bring tank into cell No. 2 with clutter gate enabled.				
029	4/5	Clutter	C. Iden	F-1 Tower using helicopter		Use interface unit to measure clutter along Bradford Mountain radial beyond 3 km. Executed clutter radial; helicopter climbing 10 deg.	Data showed break locks in both short and long pulse occurred with $\frac{S+N+C}{N+C} = 0$ dB Still broke lock at short pulse 2.1 km.	Breaks lock before end of short pulse. Noise on video		Noise a major contributor.
030	4/13	Track Sensitivity in short pulse	C. Iden	F-1 Tower		Close to tower at 0.98 km acquire & track 11 m^2 target at 350m. Acquire and track 300 m^2 target at 0.98 km. Ran radial out at +15 deg.	Short pulse tracked well adjusting MGC to its optimal value. OK. OK.			
031	4/18	Tangential sensitivity	C. Iden	F-1 Tower		Check tangential sensitivity to determine credibility of receiver.	Readings were 3 dB poorer than in Orlando bench tests. Lost 10 dB sensitivity when clutter AGC was disabled on helicopter flts on 4/12/78.			

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
							This explains losing lock before the transfer to medium pulse.			
032	4/25	Clutter map	C. Iden	F-1 Tower	M-20,MV21, 22,23	Items (4-10) objects to be mapped walking 4 deg spaced radials as described holding 100 m^2 corner reflector.				Tape speed went to 240 ips.
033	4/26	Short pulse calibration of low clutter area.	D. Bowyer	F-1 Tower		353 deg radial at 250m, 2000 m^2 & 100 m^2 targets.				Calibrate box battery holder bad.
		Tank signature data.			M-24	Put tank in place of auxiliary tgt. (σ_A) & (σ_T).				
					M-25	Tank cross section vs of tank turret (NPDE & PPD both modes).				
						Calibrate on 600 m^2 in all PPD modes.				
					End M-26					
034	4/27	Acquisition & calibration.	D. Bowyer	F-1 Tower	M-21 1st half.	ACQ Bradford Mountain.		Exciter broke lock.	Signal AGC saturated.	
		Helicopter cross section.		Helicopter assist.	Half (2nd) M-21 & M-27.	Cross section of helicopter measured.				
035	4/27	Clutter radial mapping	C. Rudolph	F-1 Tower	1/2 M-27	Placed 200 m^2 CR on helicopter did 356, 0, 4, 8 deg radials.		Exciter broke lock.		Slew not starting at 100 MHz. Adjust slew voltage of slew osc to clear problem.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
036	5/4	Acquisition & tracking	C. Rudolph	F-1 Tower	M-28	Acquisition & tracking Bradford Mountain with 2000 m^2 tgt. 600 m^2 tgt on road Kl=2.0 at 409 mi. Az=345 deg 45 min El=7 deg 45 min Signal AGC=0.23 Clutter AGC=3.55 Kl-7.0 Signal AGC=-3.0 Clutter AGC=0.7 no tgt. 600 m^2 on road (21) near small tower at 407 mi Kl=2.0 Signal AGC=0.12 Clutter AGC=-3.54 no tgt. Kl=7.0 Clutter AGC=0.8 Signal AGC=-3.1. Aux gate on 600 m^2 tgt area (small tracks) with 600 m^2 in front 100 ft R=369m Az=347 deg 45 min El=-8 deg.				
037	5/10	Exciter power test.	D. Bowyer	Alpha Radar Tower		Measure J(4) & J(5) outputs of receiver inputs sum channel circulators.	LHC was terrible. Down 6 dB from RHC measurements at freq (20, 25). Measurement taken at J5.	J3 output of S/C has bad solder joint.	Resoldered joint.	
								J2 output of S/C has bad solder joint.	J2 output of S/C is switching circulator.	
						Measure S/C characteristics.	LHC after fixing problem. A measurement at S/C J3, 3 dB from RHC.			

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
							After J2 S/C connector fixed, data looks good.			
038	5/11	Tank signature	D. Bowyer	Alpha Radar Tower	M-34, MV 35-No analog data	Ran tank up & down open field. Ran tank data at tree line.	Tracked reasonably well in NPD modes but not in PPD modes. Could not detect in NPD mode (locked on trees), instead of tank. Could at certain aspect angles 0, 90, 180, 360 deg occasionally track tank in tree line in PPD modes.			
039	5/12	Clutter mapping	D. Bowyer	Alpha Radar Tower	Video MV-36 37 M-32 analog	Identify three places where tank or other targets could be placed in tree line at various depths.				
040	6/1	PA output	C. Iden	Alpha Radar Tower		Measure output PA on thru J(4) & J(5). Check target returns.	PA=0.36A(LP) PA=0.22(SP). Circulator J5 that was replaced was backwards.	RF receiver front end.		Replaced PA. Receiver front end damage; H channel bad. Sent to vendor for repair.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
041	6/7	Noise figure. Calibration of systems checking outputs to instrumentation	C. Iden	Alpha Radar Tower		Measure noise figure.	10 dB power thru measured in bench tests.		Intermittent search switch.	Intermittent went away.
									Short pulse and angle track squares do not show up on video.	Changed gaging on crosshair circuits card.
									Video locking up to horizontal crosshairs.	Reduced horizontal crosshair level below black level.
042	7/11	PA tests.	C. Iden	Alpha Radar Tower		Measure power at various points from PA out.	Varied 0.8 MV across band measured losses in system & recorded.			
						Across freq band 1-25.				
						Freq agile on-off.				
		PA power tests S/C removed.				Replace S/C with cable measure power with no S/C.	Gained 1.9 dB replacing S/C in system with a DSM cable.			
043	7/13	Tangential receiver sensitivity	C. Iden	Alpha Radar Tower		Measure tangential sensitivity	Vertical has 1 dB power noise figure. NPD vertical is 1 dB poorer 50% PD. NPD sum mode is 1 dB different from NPD horizontal mode.	Time share circuitry intermittent.		

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
044	7/20	Transmitter phase measurement	C. Iden	Alpha Radar Tower		Measure circularity of transmitter at three freqs using linear horn V, H, +45 deg, -45 deg. Adjust sum channel J4 & J5 front end phase pots as well as J4 & J5 line stretchers to obtain optimum.	Circularity appears linear; phase adjustment needed.			
045	7/27	BTC (3-1) phase and amptitude adjustment no antenna. BTC (3-5) phase and amp alignment with antenna.	J. Scarbough	Alpha Radar Tower		Adjust J4 & J5 front end gain pots to obtain J6A2 & J6A3= J6a-1 adjusted to 165 MV; MGC= 5.5V J6A2 & J6A 3 have equal ampl; record J7a (1-4) IF processor outputs set at 165 MV. Set MARFS ant 2 deg up and rt and records JA6(2,A3) outputs.	Receiver linear & balanced for data channels for angle error processing. Without antenna signals at J6 A1/A2/A3 looks good in PPD none and PPDH. In PPD both & PPDV, MGC voltage must be decreased to get signals at J6 to be same level as before. (3)(P) error of receiver is (1) balanced in pitch up & down direction. (2)(Y) error balanced in yaw left & right (3) negative error of receiver is unbalanced.			Receiver looks OK in amplitude phase.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
046	7/29	BTC (3-1) phase and amptitude adjustment no antenna. BTC (3-5) phase and amp alignment with antenna.	J. Scarbough	Alpha Radar Tower		Same as 043.	Negative	PA only read 0.2A in short pulse; 0.35A in long pulse. Saw package was defective i.e., no output J(4)(H) channel.		PA returned to Orlando for repair; CER PA sent to us. Saw package went to Orlando & tested OK. Returned to Huntsville. Testing showed OK.
047	8/3	Receiver phase & ampl alignment BTC (3-1).	J. Scarbough	Alpha Radar Range		Same as 034.	Gains appear to be set up appropriately for equal outputs on all channels.			Saw package is OK. This realignment procedure was redone.
048	8/4	Angle error receiver check	J. Scarbough	Alpha Radar Range		IF proc. J7A8= 165 mV set to SUM (H) $\Sigma+J\Delta DAZ$ = 250 mV J7A3 rev. out. J7A8=165 mV Feed J4 (ΣH) & J2 (ΔEL)n J7A8 (ΣH) = 165 mV J5 $\Sigma(EL)$ & J2 $\Delta(EL)$	($\Sigma+J\Delta Az$) J7A3= 250 mV J7A3=100 mV J7A1=45 mV J7A1=165 mV ($\Sigma-J\Delta$)H J7A3= 165 mV Attenuator puts in too much phase.	Intermittent pitch problems; may be time share sync prob.		Pitch changes sense intermittently.
049	8/4	Receiver phase alignment with antenna BTC (3-5)	J. Scarbough	Alpha Radar Range		Same as 034.	Yaw outputs in PPD are balanced in phase & amplitude. Rain stopped test.			

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
050	8/7	Acquisition & tracking (angle & range)	D. Bowyer	Alpha Radar Range		Determine amplitude & phase alignment of MARFS after adjustment.	Pitch has wrong sense in NPD mode.			Need more adjustment; repeat amplitude angle error check & BTC (3-5).
							NPD(V) unbalanced.			
							PPD none; pitch wrong sense.			
							PPD both; AGC high & signal lower than in NPD.			Added pullup resistors to proc mode (1&2) proc mode 2 did not work correctly. Excessive current in A3 (0.5 mV). Changed IC - this fixed PPD both modes.
051	8/8	Angle error receiver check	D. Bowyer	Alpha Radar Range		Repeat 048.	Checked with 046 favorably.			
052	8/9	BTC (3-5)	D. Bowyer	Alpha Radar Range		Measure AEP AEY= 0 for GAP=0, 0.7, -0.7, 0 deg, +2 deg, -2 deg, measure AEY AEP= 0 for GAL=0, 0.7, -0.7, 0 deg, +2 deg, -2 deg off boresight in all modes.	Adjusted pots associated with pitch to obtain proper sense.			Pitch is proper sense.
							NPD balanced by adjusting phase and gain pots in vertical channel.			Vertical channels are balanced.
053	8/10	Transmitter circularity	D. Bowyer	Alpha Radar Range		To measure RHC & LHC over freq range 1-25 (Figure).	Circularity within 2 dB after adjusting phase shifters & front end phase pots J4, & J5 (ΣH) (ΣV) channels.			This balances ΣV & ΣH channels phase end amplitude.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
054	8/11	Exciter output power test	D. Bowyer	Alpha Radar Range		To check power from exciter thru J4, J5 (Figure 4).	Input to circulator in ΣV path shows large loss in cable from J3. System isolation dropped to 5.8 dB from 20 dB.	Cable failure.		Replaced cable from S/C J3 port to circulator input. Replaced isolator J3.
055	8/15	BTC (3-5)	D. Bowyer	Alpha Radar Range		See 049.	Negative.			Interchanged all H&V channels at IF output of R(X) front end to match antenna gain difference due to offset transmitter power difference.
		Transmitter circularity				Same as 053.	Same as 053.			Interchanged all H&V cables at R_x input also.
056	8/16	BTC (3-5)	D. Bowyer	Alpha Radar Range		See 040 - 1(D)	All signals are optimum aligned phase & amplitude. All AEP & AEY readings look good.			Realigned receiver so corner reflector has negative response. *Note this is after 053.
057	8/31	System calibration to instrumentation	C. Iden	Hibay Area Bldg. 5400	M-33 MV-38 MV-39	Same as 003.	Crosshairs need adjustment. AEP & AEY need more gain.			
058	9/1	Helicopter short pulse tests	C. Iden	Helicopter over heliport outside Bldg. 5400	M-34 MV-40 MV-41	Acquire & track various tgt, i.e., (600 m^2 thru 50 m^2) lock on and fly by targets. Pass over and change targets. Note: tank 50 ft behind targets.			AEP & AEY need more gain. No signal AGC. No range calibration	Circularity change made on cross bar card; 2 amps. added. Bad cable detector. Position of switch wrong.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
									No composite AGC.	Need switch bar not to disturb switches in flight test K1=1 not K1=7.
									No βA.	
									No 200 kHz control voltage on recorder.	Bell & Howell fixed.
059	9/15	Helicopter sensitivity & short pulse	R. Sullivan	Helicopter over Alpha Range	M-42 MV-43 MV-35		Locked in at 300m and flew straight up (altitude).		No audio on FOV video.	
						Sensitivity run acquire 2.35 km and fly up in alternation. Note: 50 ft target to aux gate distance.	Locked in at 2.35 km and flew into target. Breaking lock at various points. Hard to acquire on run while moving in.		Not enough gain in βA channel.	
									Crosshair pitch bad.	
060	9/16	Aimpoint wander plus sensitivity run	R. Sullivan	Helicopter tests	MV-44 MV-45 M-36		Acquired tgts at 300m.	Exciter problem - broke lock.	Camera on A scope needs adjustment.	
						Same as 056 50 ft tgt to aux gate distance.	Had problem tracking on tgts 50 ft from clutter or tanks. Range gate shifted from target (50 m^2) to aux gate as range increased from 300m.	Probality angle track slipped off 50 m^2 tgt on to aux tgt.	Need to change the pitch and yaw calibration level.	Need to go to 100m distance instead of 50m
							Locked on in sensitivity run at 2.4 km; broke lock at various points on way into target.			Need to call Bell & Howell to change recorder, amplifiers, gains.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
							See tapes. Hard to acquire on the run while moving toward target.			
061	9/18	System Check Aimpoint Run	B. Sullivan	Helicopter	MV-46, MV-47 M-37	Clarify system problems. Try full equipment run.	Helicopter nearly crashed. Exciter intermittent, but not too bad. < range track not performing well as expected.	Verify mode breaks lock if $K_1=7$ or 9. Exciter still intermittent - must be temperature problem.	TV problem easily repaired.	Inexperienced operator should explain lock problem. Switch $K_1=1$ or 2.
062	9/19	Aimpoint run	C. Iden	Helicopter	MV-48 M-38	Full aimpoint run	Successful flt. Good tracking.	No operational problems, but if $K_1=2$, gain insufficient to get good basic data.	None	System can be operated as either test bed ($K_1=2$) or seeker ($K_1=7$).
063	9/20-12/5	Returned unit to Orlando for alteration & calibration	T. Glynn			Alterations; Add H, V separate outputs. Fix exciter to make more stable. Bring out separate instrument channels. Alter blanking (Ch 6) and coupling to remove level shift problem. Shifted angle track to all Σ mode.	All alterations checked OK. System test: Amplitude balance $\pm$ 1 dB. Ø balance 0-10 deg. Unit calibrated and verified that good data could be taken.	Found lossy antenna cable. Replaced PA failed. 10/9 replaced (random diode failure).	None Used Martin instrumentation	Unit altered to operate as test bed and seeker. Thoroughly checked out.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
064	12/8-1/12	Returned unit to Huntsville to install in Helicopter, checkout	D. Deeds			Install unit. Check out. Interface with new TV.	Unit installed. Calibrated. Ran flt 1/11. Tracked fine. 50 m^2 C/R in all modes.		Load of new α on TV too much for P.S. overloaded (increased volt). FOV VTR failed. Replaced.	Unit looks ready for test sequence.
065	1/15-1/17	Instrumention & Calibration	D. Deeds			Calibration AGC, range altimeter, instrumentation calibration. Repair altimeter. Check system.	All calibrations complete. System OK.	None	Altimeter failed. Replaced IC.	Ready for flight.
066	1/18	Captive flt test Acquisition & Track	D. Deeds	Helicopter		Acquisition & Track of tank at various angular for aimpoint and range detection. Same with 100 m^2 repeater.	Acquired tank at 300-500m, elevation = 0 deg, 22 deg, 45 deg. Tracked to el = 80 deg. Tracked repeater. Investigated variability of transducer.	None	Elevated cross-hairs off screen? Intermittent audio. No analog data on tank runs.	Acquired track as good as ever. Repeater scheme works fine.
067	1/23	Captive flt test	D. Deeds	Helicopter		Obtain tank data. Run at tank in tree line.	Acquired tank. Tracked tank along tree-line.	None	Adjusted TV pedestal for crosshairs. FOV video intermittent. Replaced recorder.	System working fine.
068	1/25	Captive flt test	D. Deeds	Helicopter		Try full calibration run with repeater as ampl check. Try tank acquisition and repeater acquisition.	Acquired tank at 20 deg elevation angle. Pole agility showed no effect. Acquired 1.4 km, OK. Repeat (set for 7 dB) short pulse.	None	None	Good run.

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
069	1/26	Captive	D. Deeds	Helicopter		Additional tracking, acquired tests. Decided to install front auxillary gate.	Acquired 600 m^2 corner reflector at 1.7 km. Tracked thru transition. Installed front auxillary gate to allow tracking on corner reflector not tank, 1/27,1/28.	None	None	Run showed difficulty
070	1/29	Checkout & Captive flt test	D. Deeds	Helicopter		Check out new front auxillary gate.	Gate fine.	None	FOV video poor. Fixed.	- - -
071	1/30	Captive flt test	D. Deeds	Helicopter		Check out use of front gate in test.	Tracked repeater tank in front gate. Took fly over data runs of tank.			
072	1/31	Captive flt test	D. Deeds	Helicopter		Alternate + and - phase output of repeater. Run tracking tests.	Took data.	None	A scope intermittent.	
073	2/1	Captive flt test	D. Deeds	Helicopter		Obtain clutter data using repeater. Fix range gate and scan over 50 m^2 and treeline with MGC, manual < and fixed range.	Good clutter data. Good stable quick-look data.	None	None	Good data.
074	3/26-6/6	Installed new circuits	D. Deeds, J. Scarbough	Helicopter		New Calibration box with integral audio amplifier for improved audio.	All new equipment installed, checked out.	Timing between $\Sigma H_T \Sigma V_T$ and Σ_T was prop delay.	Blew fuse (new instrumentation made gimbal inoperative).	

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
						Create interface to view α-num TV symbology. Other instrumentation changes. Reduce blanking to allow 100m operation. Rebuild MARFS video card to interface with new α-numeric TV symbology. Install color system.		Bad dip in ΔB circuit. Replaced.		
075	6/7-6/8	Captive flt test	D. Deeds	Helicopter		Performance flight checkout of system changes.	System looked good. Stopped tests waiting for solid state amplifiers.	None	None	
076	7/9-7/11	Install amplifiers Check system.	D. Deeds	Helicopter		Verify that repeater works. Check system.	Works fine. Could not fly due to bad weather.	None	None	
077	7/12-7/13	Captive flt test	D. Deeds	Helicopter		Check boresight. Take acquisition and aimpoint data.	Boresight established. Changed altimeter scale to 5V=1000 ft.	Failure on 7/13. Antenna goes hard right when in angle track. Broken resistor fixed. Found noise high on yaw gyro input. Found wrong resistor value. Fixed. Found noise from RGY buffer	None	

Test No.	Date	Type of Test	Cognizant Engineer	Test Location	Location Data Format	Test Objectives	Test Results	Problem Seeker	Problem Instrumentation	Comments
							Performed aim-point wander on tank.	amplifer causing problem. Disconnected RGY amplifier. Note: No longer available at control panel. Found 7/19. Replaced several ICs blown while testing for RGY.		
078	7/20	Captive flt test	D. Deeds	Helicopter		Get aimpoint. Check α-num box.	Hanger door inoperative. Flight canceled. Found Q11 and driver 0002 bad. Replaced.	None	Two failures. Replaced.	
079	8/1	Captive flt test	D. Deeds	Helicopter		Alter elevation tracking gain. Take data against target helicopter. Take data on Hellfire trajectory.	Reduced rate gyro feedback. Works good. Target helicopter NOR.	Needed lower rate. Gyro feedback. Fixed.	FM/FM MUX hung in Calibration position. Replaced stepper motor.	Data looks good.
080	8/2	Captive flt test	D. Deeds	Helicopter		Take data against target helicopter. Take aimpoint data. Take tank flyover data.	Flight delayed, fog. Target helicopter NOR. Good boresight and flyover data.	None	None	Data looks good on quick look.

APPENDIX B

17 GHz TWT TRANSMITTER

Introduction

Early field testing of the MARFS system showed that the system performance was degraded by receiver noise in the ranges between 500 and 900 meters. In the ranges greater than 900 meters, the system transmitted and received chirped signals and the performance was not seriously degraded by noise again until ranges greater than 2 km were examined. Examination of the data indicated that an improvement of 13 dB in system signal-to-noise ratio in this intermediate range, and for ranges in excess of 2 km were required to obtain target and clutter signatures over the entire field of ranges out to 3.5 km without noise contamination. The most promising approach to obtain this signal-to-noise improvement is to substitute a traveling wave tube (TWT) amplifier for the present MARFS solid-state power amplifier, and add galium arsenide semiconductor (GAS) preamplifiers before the present mixers to improve the noise figure of the system.

Technical Approach

This approach utilizes a TWT amplifier (TWTA) capable of generating 200 watt pulses in the band of interest with input levels obtainable from the MARFS exciter. The present power amplifier will be removed to provide space for the added GAS preamplifiers, and the TWT amplifier and inverter will be mounted on board the aircraft. Excitation signals from the exciter on the AIMS gimbal will be routed to the TWT amplifier through semirigid and flexible cable. The output from the TWT amplifier will be routed to the switching circulator, hybrid, and circulator assemblies through fixed and flexible waveguide, converting to semirigid coax at the switching circulator.

Vendor data indicates the flexible cables are capable of operating at the higher power level. The latching circulator and 90-degree hybrid circulator performance are either unknown or marginal at the high power level and will be replaced with adequate components. The original design used mixers with added diodes to increase the power handling capability for transmitter leakage, but the added power requires limiters in the preamplifier assemblies to provide acceptable performance with the added transmitter power.

The present receiver noise figure with the associated input cables, circulators, isolators, and line stretchers is approximately 10 dB. GAS

preamplifiers are available with at least 7 dB noise figures, and combined with the 2 dB loss associated with the required input limiters, will provide at least 1 dB improvement overall. The added preamplifiers with integral limiters will be located in the volume vacated by the solid-state power amplifiers.

Summary

The added 13 dB of power and at least 1 dB of noise figure improvement will provide more than the 13 dB of signal-to-noise improvement required in a flight configuration that will permit flight evaluation of target and clutter signatures and system performance without noise contamination over the entire range out to 3.5 km.

APPENDIX C

MICROPROCESSOR BASED RADAR SIGNAL PROCESSOR

Introduction

The Multi-Environment Active Radio Frequency Seeker (MARFS) is designed to evaluate a number of radar system configurations including four modes of polarimetric processing. This scheme is handicapped in the present system configuration by forcing all RF/IF operating modes to use the same hard-wired signal processor. This approach precludes optimal signal processing in all but one operating mode.

Technical Approach

The MARFS signal processor, as presently implemented, compares gated video signals to a threshold and counts threshold crossings in each of 16 range bins on a pulse-by-pulse basis until 1000 pulses are processed. This data is then operated on using an M-out-of-N algorithm to make target present decisions. Concurrent with the 1000 pulse accumulation, the number of threshold crossings per pulse repetition interval (PRI) are also counted and used to adjust receiver gain to maintain a constant number of threshold crossings.

This technical approach to implementing a microprocessor (μP) based signal processor is to retain the hardware for those functions that are better performed by dedicated hardware and to substitute a programmable μP in place of dedicated hardware where the flexibility of a programmable device enhances the radar system's overall capability.

Specifically, the video comparators and high-speed range bin counters will be retained as dedicated hardware, since implementing these functions in a μP would stress the state of the art and provide no significant capability enhancement. The 16 range bin counters, at the end of a 1000 pulse integration period, contain digital data ideally suited for operation on by a μP. Therefore, the present hardware chain will be broken at this point, and two μPs will be inserted.

The functions to be performed by the μPs are:

1 Make target detect decisions by implementing a detection algorithm

2 Control radar operating mode (search/track/coast)

3 Control azimuth scan limits, depression angle, and number of range windows searched in the search mode

4 Control AGC voltage and/or first threshold voltage to maintain a constant number of threshold crossings

5 Man-machine interface.

The AGC/first threshold function (4 above) must be performed at a 100 Hz rate. Functions 1, 2, 3, and 5 are performed at a 10 Hz rate synchronously with the 1000 pulse integration. These two timing requirements and a system design philosophy of providing ample capacity for future system modification and expansion make it advantageous to use two microprocessors. Since the functions to be performed by the two μPs are essentially independent, this hardware implementation will be straightforward and will greatly simplify the software design.

Microprocessor No. 1 will input 16 binary words representing the number of threshold crossings in each of the range bins in the search window after each 1000 pulse integration period. This data will then be operated on by using the detection algorithm to make a target present/not present decision. The initial set of software will implement the M-out-of-N statistical algorithm currently implemented in the hardware. Sufficient computing time and program storage memory will be provided to implement and test new detection algorithms as they are defined.

Based on the results of the detection algorithm, the output of microprocessor No. 1 will be a command to the radar to either: stay in the search mode if no target is found, search the same window again if a target is detected, or switch to track mode if the presence of a target is verified by a second search of a range window. During track mode, the reverify process will continue as is presently implemented in the hardware.

In addition to the detection algorithm, microprocessor No. 1 will perform several other functions. The azimuth scan pattern will be controlled by microprocessor No. 1 to provide variable scan patterns and scan limits. The antenna depression angle will be automatically controlled, based on altitude (from the radar altimeter) and desired search range. The number of range windows to be searched will be selected based on the radar beamwidth and the search range.

The second μP will close the receiver AGC loop and adaptively set the first threshold. When the radar is operating with any amplitude information into the first threshold comparators, microprocessor No. 2 will output a properly filtered AGC voltage to maintain a constant number of first threshold crossings. The first threshold will be fixed. When the radar is in the PPD LIMIT/LIMIT mode, the AGC will be used to maintain a nominal signal level out of the phase detector. The number of first threshold crossings will be used to adaptively set the first threshold to maintain a constant number of crossings. By using a second μP to perform the calculations needed to control the AGC and first threshold, the calculations can

be performed as often as necessary to maintain the proper AGC bandwidth as determined by the detection algorithm being used. This approach also provides the flexibility to change the AGC loop characteristics as the system changes operating modes.

APPENDIX D

MARFS DIGITAL DATA ACQUISITION SYSTEM

Introduction

Integral to the MARFS system is a data acquisition system. Currently, this is comprised of various signal conditioning circuits distributed throughout the radar system, an FM/FM analog multiplexer, and a 14-channel analog tape recorder.

The present MARFS analog instrumentation system should be converted to a pulse code modulated (PCM) digital data acquisition system. This will be accomplished by replacing the FM/FM analog multiplexer with a PCM multiplexer, replacing the present video sample and hold circuits with integrated high-speed analog-to-digital converters (ADC), and adding an additional four-input high-speed ADC/multiplexer.

This change will replace obsolescent multiplexers and discrete component sample and hold circuits with state-of-the-art equipment. This will: a) increase the reliability of the MARFS instrumentation subsystem and significantly reduce the amount of retesting required due to lost data, b) make the system configuration compatible with digital data reduction systems by eliminating the requirement for an analog interface, and c) significantly increase the quantity of data recorded during MARFS tests.

Technical Approach

The MARFS digital data acquisition system employs five channels of PCM encoded data using four types of multiplexers:

1 48-channel, 100 samples per second analog multiplexer

2 Four-channel, 10K samples per second analog multiplexer

3 Two wideband video multiplexers

4 Digital data multiplexer.

Analog Multiplexer. The analog multiplexer provides 32 high-level data channels sampled at 100 samples per second. Sixteen channels are differential input and 16 are single ended. The input range is selectable at 0 to 2.0 volts or ±1.0 volt. Data is formatted into a 34-word frame with 8 bits per word and two sync words at the beginning of the frame. The serial output data is encoded in a biphase mark format at a NRZ bit rate of 27.2 kHz.

Wideband Video. Two wideband video multiplexer channels are operated from a common sequencer. Each channel operates synchronous with the repetition rate to transmit eight bits of encoded range bin data from each of four video lines. The sequencer times the sampling of the second channel to sample the four video lines either 200 ns before or after the target channel sample. Data is formatted into a 40-bit frame consisting of five 8-bit words, including an 8-bit sync word. The 400 kHz NRZ serial data is transmitted in a biphase mark encoding.

An attractive alternate data format is to sequence all the wideband video into one PCM bit stream. This approach has the advantage of automatically synchronizing all the wideband video data. The feasibility of using this approach should be investigated.

Digital Data Multiplexer. This multiplexer accepts 120 TTL inputs. The input buffers are latched and the data plus an 8-bit sync word is clocked out at 100 samples per second. The 12.8 kHz NRZ serial data is transmitted in a biphase mark encoding.

High-Speed Analog Multiplexer. Four input channels are sampled at a 10K samples per second rate. Data is formatted into a frame containing four 8-bit data words and one 8-bit sync word. The 400 kHz NRZ serial data is transmitted in a biphase mark encoding.

Provisions for incorporating an automatic calibration for each recorded signal should be made. This will facilitate system checkout and quick-look data stripout.

Interface

Four radar receiver video outputs will be processed by two high-speed digital data acquisition channels. One channel samples the four video lines at a time synchronous with the range track gate. The other channel samples the four video lines either 200 ns before or after range track time. Two serial PCM streams are generated and recorded.

The analog multiplexer samples 16 differential and 16 single-ended analog inputs 100 times a second and generates a serial PCM bit stream that is recorded. This channel will handle all analog signals currently handled by the FM/FM multiplexer and provide for recording additional analog data channels at 100 samples per second as may be required by future system modifications.

The digital data multiplexer will accommodate all discrete signals presently recorded and provide the capability to record additional discrete signals and/or binary data words as may be required by future system modifications.

The high-speed analog multiplexer provides the capability to record four analog signals synchronously with the radar PRF. System automatic gain control (AGC) and three other selected signals will be recorded on this high-speed channel.